# Engineering Requirements for Farm Structures

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**Factsheet**

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The *Building Code Act,* 1992, makes it necessary to obtain a building permit for all farm buildings in Ontario with a floor area larger than 10 $m^2$ (108 $ft^2$). The chief building official may require drawings that show more structural detail. Producers commonly ask, "Do I have to contact an engineer to obtain a detailed structural design?" This Factsheet will outline situations where further design may be required. Some of these conditions are illustrated in Figure 1.

An engineer's task is to protect humans, animals, crops, property and the environment with structurally sound, functional and cost-effective designs. They consider many types of loading and ensure that the building serves its function properly.

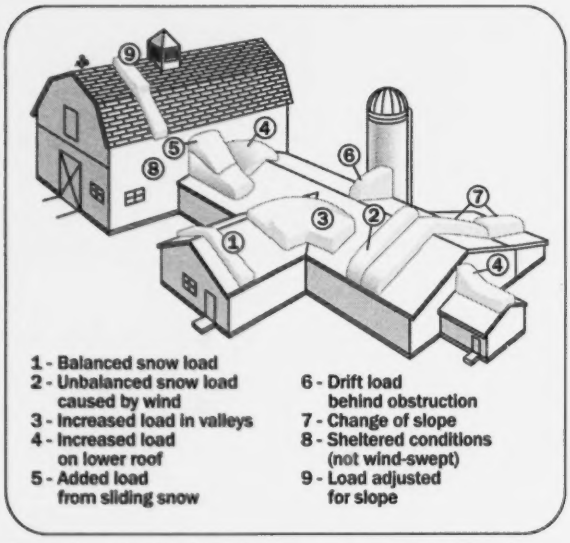
1 - Balanced snow load
2 - Unbalanced snow load caused by wind
3 - Increased load in valleys
4 - Increased load on lower roof
5 - Added load from sliding snow
6 - Drift load behind obstruction
7 - Change of slope
8 - Sheltered conditions (not wind-swept)
9 - Load adjusted for slope

**Figure 1.** Attached buildings make the design of roof structures complex. Proper snow load calculations are important. *Courtesy:* Alberta Agriculture.

Farm buildings commonly require engineering design for specific structural components (plates, post/stud sizes, bracing, footing sizes, etc.). The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) has developed standards for sizing common farm building components, as described in OMAFRA Publication 809, *Farm Building Standards for Use in Sizing Common Building Components,* available from www.publications.serviceontario.ca. The Ontario Ministry of Municipal Affairs and Housing, jointly with OMAFRA, has prepared a *Construction Guide for Farm Buildings*, available from www.orderline.com.

Simple parameters such as the building floor area or total cost are used to show how complicated a building is, but for many farm buildings, this does not tell the whole story. This Factsheet lists several questions to ask about proposed farm structures. It serves as a guide to show how complicated the design is and why building officials may request more design details. Getting answers to key design considerations early in the process can make building projects run smoother.

### Is the new building being built by an experienced farm building contractor?

The chief building official will be most comfortable dealing with a builder or contractor who has completed many similar projects. An experienced builder follows proper design procedures, is familiar with current building techniques, makes proper connections and knows best how the building must function. The complexities of constructing, temporarily bracing and finishing a large structure are best handled by a person with experience. A large percentage of building failures occur during construction.

Ministry of Agriculture, Food and Rural Affairs
Ontario

### Are standard construction methods or plans being used?

If the building official is not familiar with a proposed construction method, or if the building uses unconventional components, the official may require a detailed plan. Choosing components that can be designed using recognized design tables will simplify the process. Standard plans such as those provided by the Canada Plan Service, available for download at www.cps.gov.on.ca, are often acceptable. Engineered plans are required if the building floor area is larger than 600 $m^2$ (6,459 $ft^2$). Manure storage tanks and other structures that use reinforced concrete also must be engineered.

### Is the soil-bearing strength typical of other building sites in the vicinity?

Use proven footing and foundation systems that have performed well in similar soil conditions. Well-drained, compacted sand can support floating slab foundation systems. Contact the local building official when planning to use shallow foundation systems. Clay soils require deeper, below-frost foundation systems. For unusual soil types (soft or swelling clays, loose sand, etc.) or situations where standard design tables do not cover the situation, contact a geotechnical engineer. A geotechnical engineer will determine the bearing strength of the soil and provide recommendations for the type of foundation system to use. Project engineers use this information to design a proper foundation system. Before constructing a silo or other heavily loaded structure, obtain a report from a geotechnical engineering company.

### Is the ground floor area of the new building greater than 600 $m^2$ (6,459 $ft^2$)?

Large buildings are more complicated. Wide buildings carry very large roof snow loads. This can be magnified if rainfall occurs while the snow is still on the roof. Large trusses are more difficult to install, even in very light wind conditions. It is important to have qualified persons install the trusses. Use proper truss and wall bracing techniques (temporary and permanent) for larger buildings. All farm buildings require an engineering design for the roof system.

### Is the side wall height of the new building greater than 3.6 m (12 ft)?

High sidewalls and two-storey farm buildings are more difficult to brace (temporarily and permanently) against wind. This is one of the most common shortcomings in new farm buildings. Make sure an engineer designs any bracing system that does not use standard bracing techniques (Figure 2).

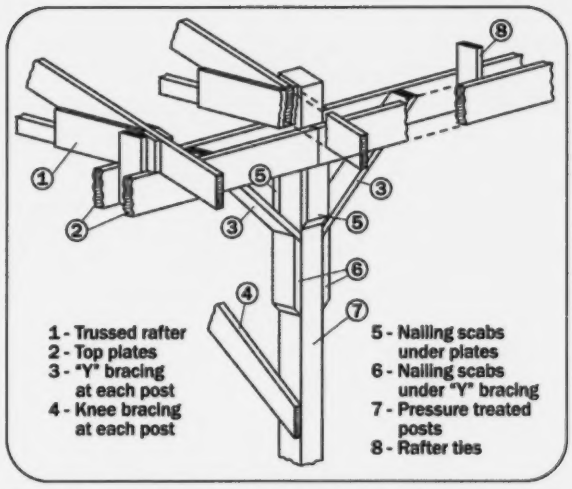
1 - Trussed rafter
2 - Top plates
3 - "Y" bracing at each post
4 - Knee bracing at each post
5 - Nailing scabs under plates
6 - Nailing scabs under "Y" bracing
7 - Pressure treated posts
8 - Rafter ties

**Figure 2.** Typical wall-framing detail for a post-frame building.

### Is the new building attached to (or very close to) another building of differing size or height?

When attached buildings, or those built closely together, differ in height, snow can slide or drift between the roofs.

For example, a one-storey tie-stall dairy barn is added to the end of an older two-storey barn. Snow can slide or drift from a higher roof to a lower one, adding large loads to the lower roof. A new lean-to (Figure 1, item 7) may add loads to an attached existing building that it was not designed to carry. The new lean-to may not be very large in floor area, but can be quite complicated structurally. Sometimes the roof is sheltered from the wind by a row of trees, a taller building or a projection such as a chimney. That roof will carry a heavier snow load since the wind cannot blow the snow away. It will need to be stronger than an unsheltered roof.

Where there is unusual loading, contact an engineer to determine the loading and recommend a design for the structural components affected by those loads.

### Are there side wall doors or openings wider than 3.6 m (12 ft)?

Roof trusses usually rest on the side walls of buildings. They transfer roof loads to the foundation and footing system through the wall frame. With typical widths of modern farm buildings of 12 m (40 ft) or more, there are large loads to transfer, which increase with increased door widths.

For example, with a total roof load of 2.0 kPa (42 lb/ft$^2$) and trusses spaced at 1,200 mm (48 in.), the load on one end of a 12-m (40-ft) truss is about 1,500 kg (3,300 lb).

Design plates and lintels spanning large wall openings accordingly. As a rule of thumb, if the opening width is doubled, the strength requirement increases by 4 times. Use steel or built-up wood beams when the spans become large.

### Are the roof trusses engineered and manufactured offsite or built on-site by a farm building contractor?

Many companies pre-engineer and manufacture roof trusses. Truss designs, bracing and anchoring techniques are complicated, especially in wide buildings. The wood connection points are critical to the design. If the roof system has multiple spans with interior posts and beams, the design for the posts, plates and bracing is critical. Always have the structural components of a roof system engineered unless standard plans or specifications are followed.

### Does the structure store or support hay, straw, bulk materials such as grain, silage, haylage, vegetables, liquid manure or other liquids?

The design of silos, bins, potato storage structures or liquid manure storage structures is critical. The consequences of a structural failure can be severe, both to the environment and to human and animal safety. These designs require verification by an engineer.

The *Nutrient Management Act,* 2002 (NMA), and Ontario Regulation 267/03 as amended, require that all new liquid nutrient storage structures be engineered. To provide a level of security for surface and groundwater, the NMA requires a geotechnical evaluation. The engineer inspects the project during construction and verifies that the structure and transfer system meet all required standards at completion.

### Does the design provide adequate and effective ventilation?

Ventilate livestock buildings to provide an environment that maximizes animal comfort and productivity. In addition to removing odours, gases and respired moisture, the system must effectively provide fresh air and help control temperature. For best results, optimize the insulating, heating and cooling characteristics of the design. For more information, see the OMAFRA Publication 833, *Ventilation for Livestock and Poultry Facilities.*

### Are fire separations required in a farm structure?

Effective building designs minimize the risk of accidental ignition and limit the severity and effects of fire on areas beyond its point of origin. The National Farm Building Code of Canada dictates that farm buildings of low human occupancy exceeding stated maximum floor areas be separated into fire compartments by vertical fire separations. For example, the maximum floor area for one-storey farm buildings of low human occupancy is 4,800 m$^2$ (51,667 ft$^2$).

Cut off concealed draft openings between storeys (and between the top storey and the roof space), by installing fire stops at floor, ceiling and roof levels. Concealed roof and ceiling space, or unoccupied attic space, must be separated by fire stops so that no dimension exceeds 30 m (98.4 ft).

### What future use requirements should be incorporated?

Thinking about future uses for the building during the design stage can save a significant amount of time and money down the road. For example, it may make sense to ensure that the roof system is oriented and structurally designed to make efficient use of solar modules. Alternatively, consider new manure treatment designs that incorporate anaerobic digestion principles. An anaerobic digester produces biogas while reducing odour and pathogens. In all cases, it is wise to consider how the operation will receive and possibly generate electricity.

### What are the environmental consequences of a structural failure?

If a liquid manure storage facility holding several hundred thousand litres of manure fails, the environmental consequences are substantial. These structures must be carefully designed and engineered. Standard plans are available from the Canada Plan Service web pages at www.cps.gov.on.ca. These plans require verification by an engineer.

Structural failure does not always mean that the building falls down. It could mean that the insulation becomes wet from a poorly designed vapour barrier, or that it does not perform to its potential. Economic losses are substantially greater if animal health deteriorates or stored crop losses result. Proper functional design is often as important as structural design.

Building codes are primarily designed to ensure that public safety concerns are addressed. "Occupancy" indicates the density of people inside a structure and how efficiently they can be evacuated. A "low human occupancy" farm building contains not more than 1 person/40 $m^2$ during normal use. For farm buildings of low human occupancy, the risk of human injury in a structural failure is lower than for a building that contains a high human occupancy. Ontario's building code and other standards are in place to try to reduce the possibility of injury or death due to structural failure.

Table 1 is a checklist of items to consider when designing a farm building. It will help explain why the chief building official may ask for more design information than originally expected. Sometimes a small design change in one area can cause undesirable effects in other parts of the building.

Every farm building is different, and each one has its own structural and functional design needs. Does your proposed farm building require special design considerations?

This Factsheet was originally written by John Johnson, P.Eng., and revised by Dan McDonald, P.Eng., Engineer, Civil Systems, OMAFRA, London.

**Table 1.** Checklist of Items to Consider in the Design of Farm Buildings

| Building component category | Detailed items | Specific design considerations |
|---|---|---|
| General | Plans | Building permits often require plans. Check with your building official. Fully engineered plans may not be required. Documentation for design of critical components may be necessary. Simple structures may only require a floor plan. Canada Plan Service plans are available at www.cps.gov.on.ca. Determine the sizing of standard farm building components. For common building sizes, check with a farm building contractor or refer to available publications. |
| | Proprietary Materials | Proprietary material selection/specification: The material supplier/manufacturer often specifies the sizes of pre-engineered material (Parallam™, Microlam™, etc.). |
| | Minimum Distance Separation | MDS II applies when locating new or expanding livestock operations and manure storage facilities. Calculate distances early in the planning process to determine if the structure is sited correctly. |
| Footings/ Foundations | Soil Investigation | Pre-engineered buildings, unusual soil types and heavily loaded structures may require a soil investigation by a geotechnical engineer. Complete a geotechnical investigation for liquid nutrient storage structures (NMA requirement). |
| | Drainage | Apply additional sub-surface drainage when improved soil-bearing strength is required. |
| Wall System | Post or Stud | Obtain a post or stud design. Use anchor bolts on stud walls and post anchors to prevent uplift of the building in high winds. |
| | Plate | A plate design is necessary. Increased post spacing (for example, from 2.4–3.6 m (8–12 ft) more than doubles the strength requirement for the plate. |
| | Bracing | For common sizes of building, a farm building contractor can specify the necessary bracing. In more complex circumstances, have an engineer specify the bracing system. For multi-storey or high sidewall buildings, the wind bracing system becomes critical. |
| | Footing & Foundation | Always obtain design specifications for footings and foundations. Use anchor bolts (if applicable). |
| Floor System | Floor Joists | Obtain a floor joist design (especially for heavily loaded floors). |
| | Beams | Obtain a design for the floor support beams. |
| | Posts/Footing | Use properly designed support posts and footings. |
| Roof System | Roof Load | Always determine roof loading. |
| | Corrosion Resistance | Protect all roofing components (gusset plates, webs) from corrosive environments. Properly ventilate the attic, select the correct building materials and/or provide an air-tight separation between the attic and the corrosive environment. |
| | Sliding, Drifting | For additions to buildings that incorporate differing roof elevations, calculate sliding and/or drifting load. If necessary, reconsider the plate/wall/foundation system because of larger loading. |
| | Trusses | For pre-engineered trusses, always ask for the manufacturer's engineering design. If building your own trusses, obtain an engineered truss plan. |
| | Roof System | Consider a full design for multi-span rafter and roof support systems. |
| | Bracing | Have an engineer specify a roof or ceiling diaphragm bracing system. |
| Doorways | Lintel | Obtain a lintel design for openings larger than 3. 66 m (12 ft). |
| | Posts | If necessary, enlarge support posts on both sides of a doorway to carry the extra loading. |
| | Footings | Properly size footings for the support posts. |
| | Bracing | If necessary, reinforce the building's bracing system on either side of a large doorway. Don't allow the doorway to weaken the bracing system. |
| Energy | Clean Energy | Ensure options for current and future clean energy production are understood (solar or biogas for example). Consider how to make future connections to the electricity grid easier. |
| | Efficiency | Design the building to use energy efficient fans/heaters/coolers/exchangers/insulating materials along with energy conservation measures in place to minimize energy use and operating costs. Complete a heat loss/refrigeration calculation. |
| Fire Prevention | Siting/ Separation | Keep hay, flammable and otherwise hazardous material storage locations separate from other compartments. Use interior finishes with low flame spread ratings. Have a plan that dictates egress requirements, fire department access and water supply locations to mitigate the impact of fire. |
| | Compartments | Respect maximum floor areas for farm buildings of low human occupancy. Break up larger floor areas into fire compartments. |
| | Material Selection | Design the electrical system components and heating/ventilation equipment for any corrosive or wet environments. |
| Special Structures | Full Design | A full engineering design may be required. Liquid nutrient storage structures will require a full design. |
| | OSA Standard | The Ontario Silo Association Design Standard is a reference document. |
| | Ventilation | Complete a livestock ventilation analysis. |

FOR YOUR NOTES

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